NATURE

A WEEKLY ILLUSTRATED JOURNAL OF SCIENCE.

"*To the solid ground*
Of Nature trusts the mind which builds for aye."—WORDSWORTH.

THURSDAY, MAY 1, 1890.

THE APPLICATION OF THE MICROSCOPE TO PHYSICAL AND CHEMICAL INVESTIGATIONS.

Molekularphysik, mit besonderer Berücksichtigung mikroskopischer Untersuchungen und Anleitung zu Solchen, sowie einen Anhang über mikrochemische Analyse. Von Dr. O. Lehmann, Professor der Electrotechnik am kgl. Polytechnikum zu Dresden. 2 Volumes, pp. 852, 697, with 624 Woodcuts and 10 Plates. (Leipzig: W. Engelmann, 1888–89.)

VERY soon after the first invention of the microscope, attempts were made to apply the new instrument to solve some of the remarkable problems of crystallogenesis. The early volumes of the Royal Society Transactions contain in the papers of Boyle, Hooke, and Leeuwenhoek, published between the years 1663 and 1709, many records of attempts of this kind; and the works of Henry Baker, which appeared between 1744 and 1764, are also largely concerned with the study of the process of crystallization under the microscope.

In Germany, Ledermuller in 1764 and Gerhardt in 1780 showed the value of the microscope in studying the internal structure of crystals; while in France a long succession of enthusiastic investigators, Daubenton, Dolomien, Fleurian de Bellevue, Cordier, and others, were busily engaged in laying the foundations of the science of microscopical petrography.

Early in the present century, we find the English investigators once more taking a leading part in applying the microscope to the study of crystallized bodies. Between the years 1806 and 1862, Brewster published a long series of memoirs, dealing with the microscopical characters of natural and artificial crystals, and the inclusions which they contain. About the year 1850, too, Mr. Sorby commenced his important investigations on the subject, availing himself of the method of preparing transparent sections of rocks and minerals which had been, shortly before this time, devised by William Nicol. Mr. Sorby's epoch-making memoir "On the Microscopical Structure of Crystals, indicating the Structure of Minerals and Rocks" made its appearance in 1858.

While one group of investigators, following the lines of the early work of Brewster and Sorby, have sought to make the microscope an efficient instrument for the determination of minerals, even when present in rocks as the minutest crystals or fragments; others have no less diligently pursued the methods which the same pioneers in this branch of research have initiated for solving physical and chemical problems connected with the formation of crystallized bodies.

In the hands of Des Cloizeaux, Tschermak, Zirkel, Von Lasaulx, Fouqué and Michel-Lévy, Rosenbusch, and other workers, the microscope has gradually been developed into a splendid instrument of mineralogical research; and the determination of the minutest particles of a mineral is now becoming no less easy and certain than that of the largest hand-specimens.

But, at the same time, Brewster and Sorby's early attempts to solve physical and chemical problems by the aid of the microscope have not failed to exercise an important influence on subsequent workers in these branches of science. Link, Frankenheim, Klocke, Harting, and especially Vogelsang (whose early death was a very severe loss to this branch of science), have done much towards establishing the science of crystallogenesis upon a firm basis of accurate observation; and their labours have been continued in more recent times by H. Behrens and Dr. Otto Lehmann, the author of the work before us.

As the well-known treatises of Rosenbusch, and of Fouqué, Michel-Lévy, and Lacroix, give us an admirable *résumé* of the present state of determinative mineralogy, as improved by the application of the microscope, so does the work before us contain a perfect summary of the contributions of the microscopist to the sciences of physics and chemistry.

It will only be possible, within the limits of an article like the present, to indicate briefly the plan of the very comprehensive, and, indeed, almost exhaustive work, in which Dr. Lehmann has embodied the observations of himself and his predecessors in this field of inquiry.

The first division of the book deals with the construc-

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tion and use of the microscope; especial attention being given to forms of the instrument, like those devised by Nachet and by the author of this work, for the special purpose of studying crystallization and other physical and chemical processes.

The second division of the book treats of those physical properties of matter which are presented by all bodies, whether in the solid, liquid, or gaseous state. Such questions as the polarization and absorption of light, the conduction of heat, and the electric and magnetic relations of various substances are here dealt with by the author.

The next division relates to the peculiar properties presented by solids. Elasticity and plasticity are considered, and, under the latter head, the remarkable phenomenon of the production of twinned structures in crystals by mechanical means is fully discussed. Under the head of cleavage we find a treatment of such phenomena as the production of mathematical figures in certain crystals by pressure, percussion, &c. ; while under the heads of "Enantiotropie" and "Monotropie" are classified the consequences which follow from heteromorphism among crystalline substances, and the tendency of the heteromorphous forms to pass one into the other.

The division dealing with liquids and their peculiar properties contains discussions on fluidity, surface-tension, diffusion, capillarity, and crystal-growth, with the origin of structural anomalies. The problems of solution and precipitation, with those of solidification and fusion, are also treated of in this part of the treatise.

The second volume of the work commences with the discussion of the properties of gases and their relations to solids and liquids. This division of the subject, which is very exhaustively treated, extends to 335 pages.

The work concludes with critical remarks upon different molecular theories. The chapters dealing with the theories of crystal structure, of allotropy, of heteromorphism, and of isomerism, with several others, in the same division of the book, are full of interest and suggestiveness.

A supplement of about 150 pages is devoted to what the author calls "crystal-analysis," or what is generally known to geologists and mineralogists as "microchemical analysis." Very minute particles of an unknown substance may often be determined by being treated with appropriate reagents and studied under the microscope; in this way they are made to yield crystals of various compounds which can be recognized by their characteristic forms and habit. An admirable summary is given by the author of the work of Bôricky, Streng, Behrens, Haushofer, and others, who have gradually perfected this branch of research, and made the method one which is of the very greatest service to the students of microscopical mineralogy and petrography.

While the physicist and chemist will find in this work a perfect mine of interesting and ingenious experiments (many of which are suited to class-demonstrations by projection methods), the mineralogist and geologist will hail the appearance of the book as one that completes and supplements the well-known treatise of Vogelsang—a work that has exercised the most important influence on the development of petrological theory.

In conclusion, it may be pointed out that, not only are the numerous observations of the author on crystallogenesis that are described in memoirs in *Groth's Zeitschrift* included in the work before us, but many others that have never before been published find a place in these volumes. The work is very fully illustrated both with woodcuts and coloured plates, and constitutes a complete synopsis of all that is known on a number of questions of great importance and interest to workers in many different branches of science.

BERTRAND ON ELECTRICITY.

Leçons sur la Théorie Mathématique de L'Électricité, professées au Collège de France. Par J. Bertrand. (Paris: Gauthier-Villars.)

THIS book contains lectures on electricity given by M. Bertrand at the Collège de France. In his preface the author states that he has confined himself to the mathematical principles of the subject; but this hardly expresses the limitation he has imposed upon himself, for a great many results which English students of electricity are accustomed to find in text-books on this subject are omitted from this work. A brief description of the contents of the book will suffice to show this. The first chapter contains an investigation of the attractions of spheres and spherical surfaces when the law of attraction is inversely as the square of the distance; the second and third are devoted to the properties of the potential; the fourth contains an investigation of the conditions under which the method of lines of force can be used ; the fifth, which has the comprehensive title "Électricité Statique," contains a short discussion of the electrical distribution on two spheres which mutually influence each other, the reciprocal theorems, and a discussion of the properties of the Leyden jar so far as they can be discussed without introducing the idea of specific inductive capacity ; the sixth chapter contains some remarks upon magnets ; the seventh treats of Ohm's law, and contains Kirchhoff's equations for the distribution of currents amongst a network of conductors, without, however, any applications even to such an important case as that of Wheatstone's bridge ; the eighth, ninth, and tenth chapters contain, respectively, investigations of the magnetic forces produced by linear currents, the laws according to which such currents act on each other, and simple applications of these laws ; the eleventh chapter contains some account of the induction of currents, and, amongst other things, some well-founded reasons for not deducing the laws of induction from the principle of the conservation of energy alone, but no hint is given of the possibility of regarding a system of currents as a dynamical system, though the introduction of this idea by Maxwell has thrown new light over the whole subject and enabled many of the properties of currents to be recognized at once as those belonging to any dynamical systems ; the twelfth chapter contains some account of the application of the results of the previous chapters to dynamo-electric machines ; and the thirteenth and last chapter discusses units.

There are two views which have been taken as to the relation between the mathematics and the physics, which ought to exist in a text-book on mathematical physics : the one is, that it is the province of physics to supply the

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